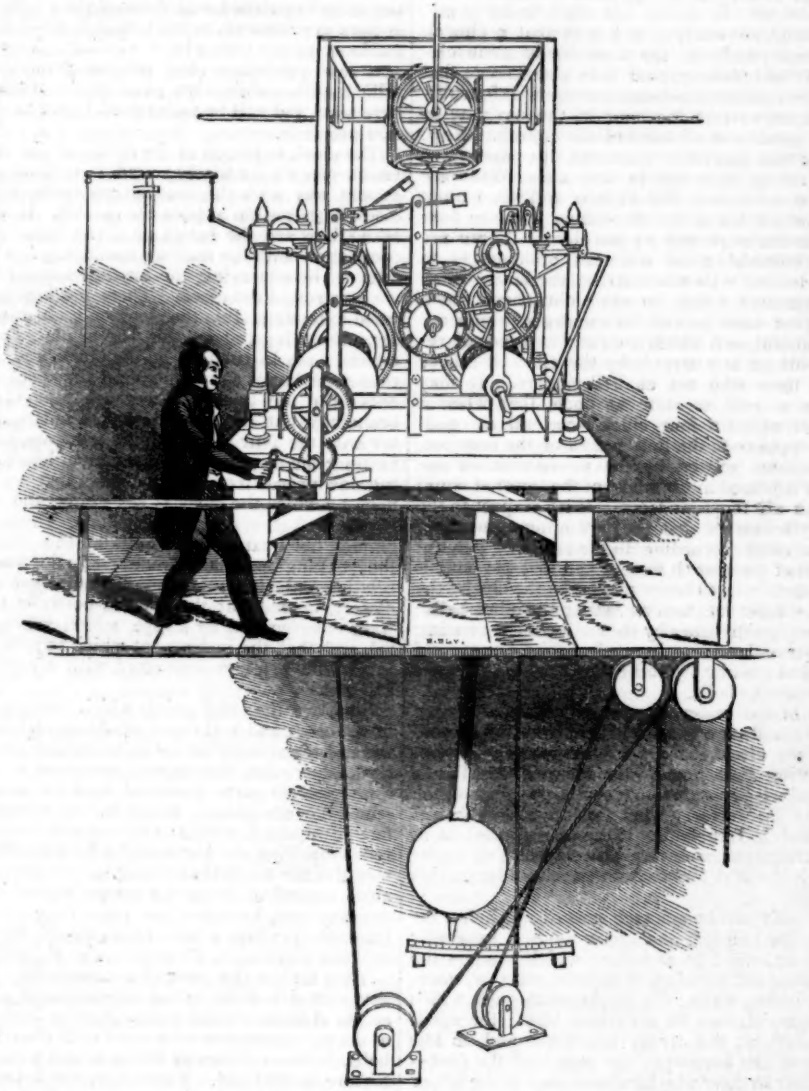
CHURCH-CLOCK FACTORY AND BELL-FOUNDRY.



[Clock of St. Ann's Church, Limehouse.]

HAS the reader ever visited the belfry or the clock-room of a church tower? An hour may be spent in such a spot, if not merrily, at least pleasantly and profitably. There is food in such a place for contemplation of many different kinds. We are elevated far above the busy hum of street traffic, and can forget for a moment the world and its multitudes. We are in a room devoted to old Father Time, whose movements are measured by the work of men's hands, and whose hourly progress is recorded in tones which ring loudly through the church tower—progress which, however, Young doubts our power to value at its proper price:—

"On all important Time, thro' every age,
Tho' much and warm the wise have urged, the man
Is yet unborn who duly weighs an hour."

We have beneath us a silent building whose purpose is of a solemn and sacred nature, and the invitation to which is sounded on the bells in the room where we are standing. The mournful tones which announce the consignment of a lifeless body to the grave, and the merry peal which lends its aid in times of rejoicing, alike emanate from the belfry. We may then turn our attention to the mechanism by which these effects are produced; and in proportion to our comprehension of the details, so will be our admiration of the skill displayed in the combined results.

Having recently paid such a visit as is here alluded to, we have thought that it might be made the theme of an article not wholly destitute of interest and of instruction. The philosophy of church clocks and bells

is a large subject; but it may be possible to give such an epitome of the mode of manufacture, the mode of action, and the mode of arranging these pieces of machinery, as to convey a few general notions on the matter.

In the first place, everybody knows that a church clock is generally fixed in the tower, or in some elevated part of the building; and it is also known that many churches exhibit clock-faces or dials in four different directions, so that the hour of the day may be observed by persons on all sides of the church. Now, we doubt not that many who may read this paper have entertained the opinion that in such a case there are four clocks, one for each dial or face, and who cannot conceive how all the four hour-hands and the four minute-hands can be moved by one clock. There are also, it is probable, many different opinions as to whether the bell or bells which strike the hour, which chime the quarters, which (in some churches) play a psalm or hymn tune at certain intervals, which are tolled at a funeral, and which are rung at times of rejoicing, are all, or any, struck by the clock itself, or whether by men who act as bell-ringers. It may therefore be as well to state at once, that when a church tower exhibits four clock-faces, all at equal height, and opposite to the four points of the compass, all the hands are moved by the mechanism of one clock, which is placed in the midst of the tower at equal distance from all the four faces. With respect to the bells, it may be stated that they are hung either over or under the clock, according to the size and general arrangement of the church tower; and that the hour is struck on a bell by a hammer moved by the clock; the quarters by similar mechanism acting on other bells; the psalm or hymn tunes by the action of a rotating barrel similar to those seen in musical snuff-boxes; and the tolling and pealing by bell-ringers, who pull ropes connected with the bells.

There is in the eastern part of London a church clock which stands at a greater height from the ground than any other clock in or near the metropolis—not even excepting that noted city monitor St. Paul's clock, and which presents four very large faces on the four sides of the tower. This clock, which is that of St. Ann's church, Limehouse, is the one alluded to in a former paragraph; and we perhaps cannot do better than make it the text for what we have to offer on this subject.

The value of room in a church tower is such that the approach to the bell-loft and clock-room is generally narrow and awkward to a degree which renders the ascent anything but inviting. The short, narrow, steep, dark, and winding stairs; the loopholes through which the wind finds entrance in a cutting blast; the small doors and outlets; the dreary loneliness and no less dreary echo of the footsteps; the cold and the dust—all are familiar to those who have ascended to the upper part of St. Paul's cathedral, and are almost equally observable in other church towers, including the one to which our attention is here directed.

On ascending to a height of about a hundred and thirty feet, in the tower of Limehouse church, we find ourselves in the 'clock-room.' This is a square room, bounded on the four sides by the thick walls of the tower, and having a wooden flooring on which the clock rests. The light is very limited, and it is not till the eye has become a little accustomed to the gloom that the objects in the room are discernible. The clock is seen to be enclosed in a wooden case, about eight feet high, six feet wide, and four feet deep, the two opposite sides of which may be thrown open by means of folding-doors, thus exhibiting a complicated assemblage of wheel-work and other mechanism within.

Our frontispiece is so drawn as to show the general arrangement of the clock and its mechanism. The clock contains about thirty wheels, some of which govern the motion of the hands; others the striking of the bell. There are two barrels, from which weights are suspended by a cord, and the mode of winding up these is here represented, as well as the small dials for the guidance of the man who is winding. The rod which acts as a pendulum (but not the pendulum bob itself), together with other parts of the mechanism, are here seen, and will be understood better as the description proceeds.

The clock is placed in the centre of the room, and a visitor can walk entirely round it, without interfering in any way with the mechanism connected with the clock-faces visible outside the church. It may then be asked, how are the hands on these faces brought into connection with the moving machinery? We find an answer, by observing the arrangements overhead, as we pass round the clock. There is a horizontal bar of wood extending from the clock on each side to the wall opposite to it; and on this bar is placed an iron rod, which is set in rotation by the clock, and, in its turn, causes the hands to rotate round the clock-face on the outside of the tower. There are four of these rods branching out from the clock in a horizontal position towards the four points of the compass, each rod governing the movement of one pair of hands. On looking downwards from the clock-room we see the mechanism by which the clock is set going, and also that by which the bell is struck every hour. There are neither chimes nor quarter-hour bells at this church, so that the striking machinery connected with the clock has relation only to one bell. Examining a little more closely, we see that the moving-power is a heavy iron weight, suspended by a rope, which coils round a barrel, and that the instrument which strikes on the bell is an iron hammer connected with a series of levers and rods.

Such are the chief points which become observable in the clock and bell tower of the church here alluded to; and if any other of the metropolitan churches were similarly visited, they would be found to contain the same general parts, modified by the circumstances in which they are placed. Some, in which only one clock-face is required, would not have the four connecting rods branching out horizontally from the clock; others would have the bell and striking machinery above the clock instead of below it; others would be without a wooden case, provided the room were close and free from dust; while others again would have additional striking machinery, for quarters or chimes.

Thus far for the general arrangement; and now we may attend a little to the manufacture and mode of action of these several parts. Not the least remarkable of the circumstances connected with church clocks and bells, is the very narrow limits within which the manufacture is confined. There are, we believe, only two establishments in the metropolis at which church clocks are made, and only one church-bell foundry. The cause for this limitation may perhaps be sought in the comparatively small number and long duration of these pieces of mechanism. New churches shoot up but slowly, and old ones do not have a renewal of clocks and bells except at long intervals. We have been favoured by the proprietors of one of these two clock-factories, and of the bell-foundry, with such details and facilities as may be necessary for our present purpose. Messrs. Moore and Co., at their clock-factory in Clerkenwell Close, have preserved a list of the church and turret clocks made at their establishment during the last forty years; and a glance at this list shows how small is the number of these large clocks required, compared with clocks of smaller dimensions. Out of eleven or twelve thousand clocks made at this factory

during the space of time here mentioned, between three and four hundred were church or turret clocks, and the remainder house and musical clocks: yet these three or four hundred have required mechanism and manufacturing arrangements so extensive, that we can easily see why the manufacture of church-clocks should be in few hands.

Neither a pocket-watch, nor an eight-day dial, nor a common Dutch clock, will exactly convey an idea of the construction of a church-clock; for, instead of being moved by a spring, as the two former, it is moved by a weight; while on the other hand its accurate finish of workmanship is wholly unrepresented in the Dutch clock. Generally speaking the frame-work of a church-clock is made of iron, the principal wheels of brass, and some of the pinions and finer work of steel. The arrangements of the maker are therefore regulated according to the number and parts of the clock made at his factory. Whoever has seen a watchmaker at work, must have observed the extreme minuteness of his tools and working apparatus; but such a person is not strictly a *maker* of watches; he only puts together and adjusts and repairs the various parts which have been made by many different hands. In the clock-manufacture, and especially in church-clocks, this subdivision of employments is not carried out to nearly so great an extent. At Messrs. Moore's factory almost every part of the mechanism of a church-clock is made within the establishment, except the rough castings in iron and brass. In the smith's shop all the forging and filing of arbors, bars, and other works of iron, are effected; as well as the case-hardening of the finished pieces. In the wheel-cutting shop is carried on the beautiful operation by which the teeth of wheels—that important department of all such manufactures as this—are cut. In other shops the general fashioning and adjustment of the numerous pieces which form a clock are effected, aided by various pieces of mechanism, such as lathes for turning brass, iron, and wood, drills, revolving machinery, polishing apparatus, &c. Those who are accustomed to factories of this kind will easily understand the appearance and general arrangement of such a place; those who are not, must conceive thirty or forty men working on pieces of metal which require great skill and care in their preparation.

Without attending particularly to the classification which a clock-maker would lay down, we will separate a church-clock and its mechanism into five parts—1st, the moving-power; 2nd, the 'movement' or going wheels; 3rd, the regulation, or pendulum arrangements; 4th, the indication, or mechanism connected with the hands; and 5th, the striking machinery. Any attempt to follow the minute details of clock-making would be quite out of the question, and will not be made here.

First, then, the *power*. Every child knows that the old familiar clock, which has perhaps formed one of the household inmates as far back as he can remember, is 'wound up' occasionally, not by turning any wheel or handle, but by elevating an iron weight to the height of the clock; almost every child knows that the little pocket-watch, whose tickings excite such astonishment in his mind, is 'wound up' by means of a very small key; but there are many children of larger growth who are utterly at a loss to know what this winding-up really means. The main body of a clock or watch consists of many wheels which work one into another, insomuch that if one wheel moves, the others are drawn into motion by it. But there must be something to impart this motion in the first instance; and this is called the *power*. We know that if the pendulum of a common clock be stopped, the clock is stopped at the same moment; and that the movement of the clock is renewed when the oscillations of the pendulum are renewed. Hence many persons may suppose that the pendulum is the source of the clock's motion. Again, there are stop-watches in which, by moving a little pin, the watch may be made to stop; and then, by a contrary movement, the going of the watch may be renewed; and hence the pin seems to be the source of motion. But both these suppositions are erroneous. In both these cases of stoppage, the rotating wheel-work is checked by a small piece of mechanism, and the motion is renewed when the check is removed; but the *production* of the motion is a totally different affair. In a common pocket-watch, the key by which the winding-up is effected is placed on a small piece of mechanism called a 'fusee,' from which a chain extends to a brass box or barrel. This barrel contains a fine and highly tempered steel-spring, which becomes coiled up very tightly by the rotation of the fusee and the winding on it of the chain from the barrel. This tight coil is so different from the natural state of the spring, that the latter exerts a powerful pulling force in its endeavours to regain its original position; and this force tends to make the barrel in which it is fixed rotate, because by this means only can the original state of the spring be regained. When once the barrel is made to rotate, that rotation can be communicated, by toothed wheels, to other mechanism. Such is the source of power in pocket-watches, in chronometers, and in the dials which are now so much used in public buildings and large apartments.

In church-clocks, turret-clocks, and common house-clocks, there is no such spring as that alluded to in the last paragraph. There is a line or rope, descending perpendicularly from a particular part of the wheel-work, and having an iron weight suspended from its lower extremity. The iron appendage of course exerts a gravitating force in proportion to its weight, and descends gradually; but from its mode of attachment, it cannot do so without causing the rotation of a barrel round which the cord is wound. When the pendulum is stopped, either purposely or accidentally, a catch or detent falls into such a position as to prevent the rotation of the barrel; but this obstruction being removed, the barrel rotates so long as the weight descends; and this rotation is communicated, by toothed wheels, to other mechanism. When the weight descends to the floor, or when all the cord is unwound from the barrel, the clock must stop; but before this time arrives the machine is wound up by causing the barrel to rotate in an opposite direction, by which the cord becomes rewound upon it, and the weight elevated.

In a house-clock the weight is so small that the winding-up is effected easily by pulling a small handle; but in larger clocks the aid of a winch or windlass is required. The length of the cord is proportioned to the diameter of the barrel, and to the time which the clock is intended to 'go' between each two windings; and is, in a church-clock, very considerable. At the Limehouse clock, which was made two or three years ago by Messrs. Moore, the time of going is, as in most church-clocks, eight days, and the weight by which the barrel is made to rotate amounts to about sixty pounds. The line does not fall perpendicularly from the clock to the weight, but passes over two or three pulleys for economy of space.

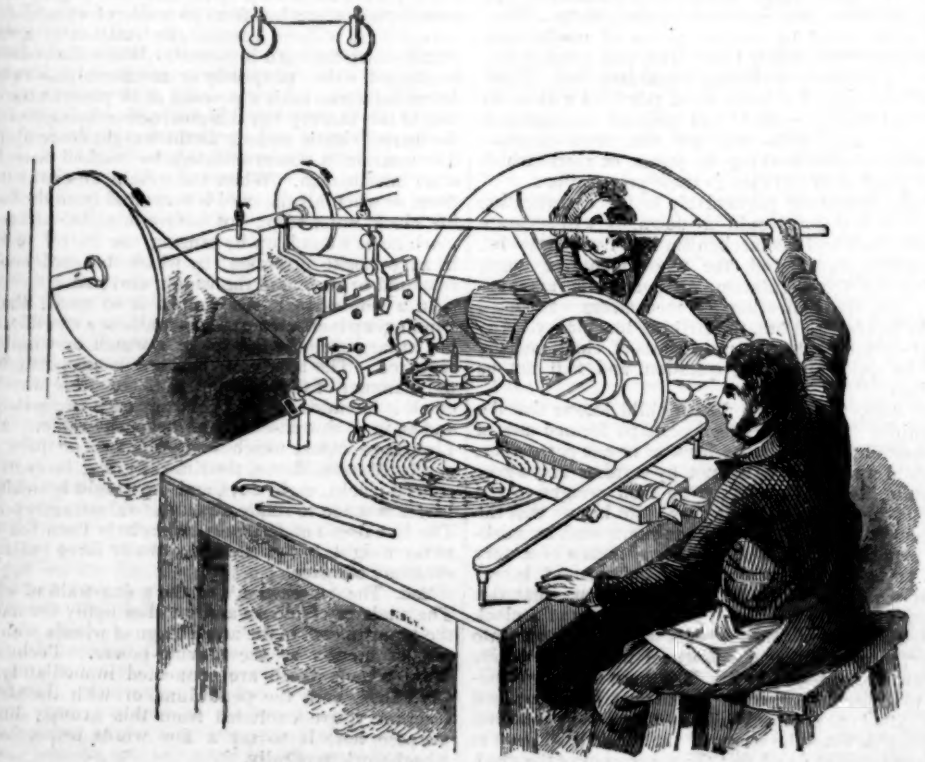
2nd. The '*movement*,' or the going-train of wheels. The makers of clocks and watches apply the name of the 'movement' to the assemblage of wheels which are put in motion by the moving-power. Technically, those wheels which are connected immediately with the hands, with the pendulum, or with the striking machinery, are excluded from this group; but our purpose here is to say a few words respecting the wheel-work generally.

Almost every wheel in a clock has teeth or notches

cut in its circumference. Sometimes these teeth stand out radially from the edge; sometimes they are perpendicular to the plane of the wheel; sometimes they nearly resemble the teeth of a saw; but whatever be the varieties, a glance at the interior of a clock or watch will show that almost every one has these indentations in some form or other. This is one of the modes adopted in general mechanism, for communicating motion from one wheel to another; pulleys, straps, and bands being inconsistent with the minuteness of a clock or watch. In some cases two adjoining wheels work into each other, the teeth of one interlocking in those of the other; but in other cases a small number of teeth are cut in the pinion or axis of one wheel, which work in the teeth at the circumference of the other wheel; and indeed it is in this latter way that a difference of velocity is generally attained. If, for instance, a wheel with fifty teeth work into a pinion of ten teeth, the pinion will rotate five times as fast as the wheel, and thus becomes a source of higher velocity. The great point of attainment in the 'movement' of a clock or watch is, that one particular wheel shall rotate exactly once in an hour; this being effected, the arrangement of the hour and minute hands becomes easily determined. The proportions of the teeth in all the wheels and pinions is therefore so fixed as to lead to this rate of movement. In the Limehouse clock the barrel, which is a solid cylindrical block of elm, about eighteen inches in diameter, is attached at one end to a toothed wheel, about two feet in diameter, which rotates with it; and this rotat ng wheel forms one in a train which leads to the hourly rotation of one particular wheel.

The manufacture of the 'movement' or 'going-train' of a clock or watch consists, therefore, principally in the careful preparation of toothed wheels and pinions. These wheels are made sometimes of brass, and in others of gun-metal, while the pinions are of case-hardened steel. With respect to the factory before mentioned, the wheels are brought thither in a very rough state, just as they are produced by the caster or founder, consisting merely of a circular rim, connected more or less with the central part through which the axis is to pass. The whole manufacture of the wheel from this rude germ is then effected in the shops of the factory. There are lathes for giving to the wheel a perfectly true periphery, by means of sharp steel tools; various pieces of mechanism for shaping, smoothing, and polishing every part of the surface; and, lastly, a very beautiful engine for cutting the teeth.

The cutting-engine is represented in the annexed cut. There is one part of the mechanism for cutting the teeth, and another for regulating their distance one from another. At Messrs. Moore's factory there are two of these engines, one moved by a foot-treadle, and the other by a winch-handle, but the essential mechanism is the same in both. A horizontal rod or bar is made to rotate on its axis with great rapidity; and at one part of its surface is fixed either a wheel or a small sharp piece of steel, corresponding in shape to the teeth about to be cut in the brass wheel. The latter is fixed horizontally on a stand, at such a distance from the cutter that the latter can just reach it in the course of its rotation. The amazing rapidity with which the cutter rotates enables it to cut through the brass with great ease, the pressure or contact being regulated by a lever which the workman moves with his right hand. Cutters of various shapes and



[Wheel-cutting Engine.]

sizes, but all made of hardened steel, are provided for the cutting of different kinds of teeth. When one tooth is cut, the workman shifts the wheel round a little, to present a new portion of the circumference to the action of the cutter; only one tooth being cut at a time. The extent of this shifting is managed thus:—A brass plate, lying horizontally on the bed of the engine, is marked with a great number of concentric circles, each of which is divided into a number of precisely equal parts, the number being different in the different circles. One circle, for instance, is divided into forty-eight parts, another sixty-four, a third seventy-two, and so on, as may be found most advantageous. If a wheel is to have any number—say sixty-four—teeth in its circumference, a lever is so adjusted that a sharp point at its extremity shall just reach the circle which is divided into sixty-four parts, and as there is a little hole made in the plate at each of these divisions, the sharp point attached to the end of the lever will drop into all these holes in succession, as the plate revolves. The revolution of the wheel which is to be cut causes also that of the divided plate, and the workman knows, by the dropping of the sharp point into one of the little holes, when he has shifted round the wheel to a sufficient distance.

No one who has not closely attended to the matter can conceive the difficulty which has been experienced in thus dividing circles into any number of rigorously equal parts. All the resources of art shown by Ramsden, Troughton, and other eminent mathematical instrument-makers, have been required in the division of circles for astronomical instruments; and although such strict accuracy is not required in common clock and watch wheel-work, yet the amount of skill required and shown therein is sufficiently striking.

Whether the teeth be cut in brass, in gun-metal, in iron, or in steel, whether they are in the wheel itself or in the pinion, and whatever their shape may be, the cutting is effected nearly in the same way, and is succeeded by various finishing and polishing processes requisite for the accuracy of the wheel's motion. Here then we may leave them and proceed to,

3rd, The *indication*, or mechanism connected with the hands. The dial-plate, or rather, face of a large church-clock is generally of wide dimensions, as a means of making its indications conspicuous from below. The four clock-faces at Limehouse church, for example, are each thirteen feet in diameter, with hands and figures of proportionate size. The hands are made of copper, and weigh about sixty pounds the pair. Each hand has, at the extremity opposite to the pointed end, a heavy piece of copper sufficient to act as a counterbalance, and to allow the hand to obey the motion of its axis; this counterbalance is generally painted black, to render it less visible. The arrangement of the mechanism connected with the hands may perhaps be understood from the following description. It will be seen in the frontispiece that at the upper part of the clock is a horizontal wheel, which gives motion to four wheels at right angles to it. These four wheels are connected respectively with the four horizontal rods which proceed from the clock to the faces. Each of these rods, which are about eight feet long and three-quarters of an inch thick, rotates once in an hour, and communicates that rate of motion to the axis or pinion on which the minute-hand is placed. Other wheel and pinion work so modifies this motion as to make another axis rotate once in twelve hours; and in this latter is fixed the hour-hand. It will therefore be seen that the sole source of the movement of the hands is the rotation of the iron rods which extend across the clock-room, and that the mechanism of the clock sets these rods revolving.

Of the face itself we may observe, that in most instances it is made of copper, painted and gilt in a more or less ornamental manner. Others are made of slate; and in some cases the face consists of a circular depression cut in the stone-work of the clock-tower, with figures either painted and gilt on the stone, or cut in relief. The making of the wheels and pinions connected with the clock-face is the work of the same class of persons as those employed in the 'movement' wheels; while the decorative parts devolve upon the 'clock-face gilder.' The dial-plates used for the smaller kind of clocks are very different from these: in some cases they are made of brass, brought to a fine surface, and silvered, with figures and inscriptions cut in the metal by the 'clock-engraver;' while in other instances the face is made of sheet-copper, coated with enamel, and having figures and letters painted in enamel of a different colour, the work of the 'dial-plate enameller' and the 'enamel-painter.'

4th. The *regulation*, or pendulum arrangements. We cannot perhaps better illustrate the use of these portions of a clock's mechanism than by asking the following question: Why does not a clock run down in a few hours, when so heavy a weight as sixty or seventy pounds is constantly urging it? Such would be the case if there were no regulating machinery. In a common vertical pocket-watch we see under a perforated cover a bright steel wheel rotating, or rather vibrating, horizontally; in a common clock we see, instead of this, a pendulum oscillating to and fro. The mechanism in the first case is known by the general name of the *'scapement;* and however different in appearance, the object is the same as that attained by the pendulum of a clock. A spring with a given degree of tension, and a pendulum of a given length, each requires a certain time for the performance of an oscillation; and this important law is made to regulate the movements of the wheel-work in a clock or watch. The steel wheel in a watch is called the 'balance-wheel,' and is governed by a fine spring lying beneath it; but we will here confine ourselves to the pendulum arrangements of a clock. All church-clocks have a long wooden pendulum or staff, to the lower end of which a mass of iron is attached. In the Limehouse clock, for example, the pendulum rod is about thirteen or fourteen feet long, and to the lower end of it is attached a mass of cast-iron shaped like a double-convex lens, about thirty inches in diameter, and weighing two hundred pounds. This is suspended from the frame-work above, and acts in the following manner:—As the wheels revolve, one part of the mechanism gives an impulse to the pendulum, by which it is set in motion. As soon as that impulse has ceased, another urges the pendulum in the opposite direction, and thus the oscillations are produced. But as the pendulum, from the law which governs its movements, has a tendency to make all its oscillations in equal time, it acts as a regulator to the motion of the wheels, and gives it uniformity. As a ball, rolling down an inclined plane, would move more and more rapidly every second, so would the rotation of the wheels in a clock increase in rapidity every second, were it not that the pendulum absorbs, as it were, all this increase of velocity by increasing its own extent of oscillation, leaving the *time* between every two oscillations unaltered. It is this equality of time in the movements of the pendulum which produces and maintains equality in the movements of the wheels.

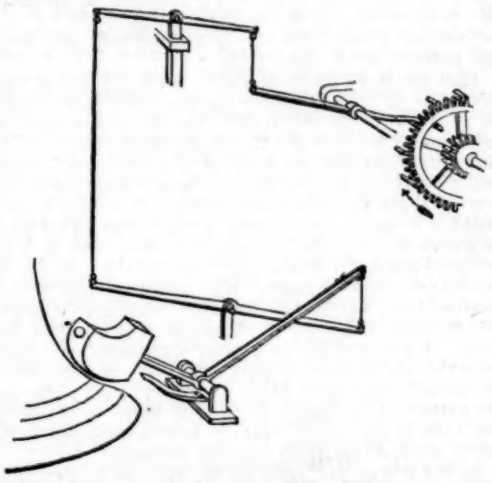
The mechanism connected with the pendulum is not very extensive. The rod is a plain piece of wood, squared and smoothed for the purpose. The mass of iron, or 'bob,' is cast to the required shape and size, and has an adjusting arrangement by which it can be attached to the rod at any part of its height. In some church-clocks, as seen in our frontispiece, there is a

graduated arc to measure the extent of the vibrations, which varies with the moving-power. At the upper end of the pendulum are small pieces of mechanism, in iron and brass, by which the rod is brought under the influence of the wheel-work, and set into oscillation. The 'bob' of a church-clock pendulum, from the necessary length of the rod, is in most cases beneath the room in which the clock itself is contained.

5th. The *striking* machinery. Our clock has hitherto been a silent monitor. We have offered a few items of explanation as to the manner in which it shows to the eye the progress of time; but there is an appeal to the ear which is equally worthy of notice. Every one knows that church clocks differ greatly in the number and frequency of the sounds emitted from the bells. Many clocks only strike the hour, proportioning the number of strokes to the hour of the day; others, in addition to this, announce the quarters, by two, four, eight, or some other number of bells, all bearing a certain musical relation one to another; and a third kind play some particular hymn or melody at certain intervals of time, on eight or ten bells. But all church-clocks, with very rare exceptions indeed, have a bell on which the hour is struck.

It will easily be conceived that if a bell be hung in a particular spot, and a lever with a hammer at the end be placed near the bell, the lever may without difficulty be so influenced by the wheels of the clock as to cause the hammer to strike the bell. But to cause exactly an interval of an hour to elapse between two such strikings, and to make the number of blows on each occasion correspond with the hour of the day, require mechanism almost as complicated as that by which the indications of the hands are produced. Still greater is this complication when the clocks chime the quarters; and when a regular melody is performed on the bells, the arrangements are proportionally more intricate.

In the first place it must be clearly borne in mind that there is a separate moving-power for the striking-machinery, similar in principle to that which impels the going-train. In an eight-day dial, for example, there is one spring-barrel and fusee for the going-train, and another, nearly the same in form and size, for the striking-train. In a church-clock, and in common Dutch clocks, there is one iron weight for the going-train and another for the striking-train, each weight having a cord and barrel appropriated to itself. If we notice the movements of a common domestic pendulum-clock, we shall see that while one of the two weights is continually descending at a slow rate, the other descends only while the clock is striking; it is the descent of the last-named weight which causes the striking of the clock, and this striking would be continuous if there were not checks to the descent of the weight. For a large church-clock, where the tones of the bell could not be clearly elicited, except by blows from a heavy hammer, the moving-power of the striking machinery greatly exceeds that of the going-train In the Limehouse clock the going weight is about sixty pounds, whereas the striking-weight is a mass of iron weighing five hundred pounds, and the hammer-head fifty-six pounds. This heavy mass is attached to a rope which winds round a solid wooden barrel, of nearly the same diameter as the barrel before spoken of, and this barrel gives motion to a train of wheels by the customary tooth and pinion work. The motion, however, is checked by a catch or detent, except at the termination of each hour, when a curious piece of mechanism connected with the going-train releases the striking machinery, allows the weight to descend, and causes the hammer to strike the bell. Whether the bell be above, below, or at the side of the clock, the connection between the striking-wheels and the hammer is easily made by levers and pulleys; at the Limehouse clock the bell is beneath the other parts of the mechanism. The mechanism in immediate connection with the hammer and bell of the Limehouse clock is shown in the annexed cut.



[Striking-apparatus of a Turret-Clock.]

But although the release of the striking machinery causes the descent of the weight and the percussion of the bell, yet this does not determine whether the strokes shall be one or many. This is determined principally by two pieces of mechanism called a 'snail' and a 'rack,' the intricate action of which it would be in vain to attempt to explain here. Suffice it to say, that the time during which the striking weight is allowed to descend, varies at different hours of the day; it being sometimes only long enough to permit one blow to be given by the hammer on the bell; and at another time long enough for twelve such blows.

When the clock indicates the quarter-hours on two or more bells, an additional piece of mechanism is necessary, which releases the hammers of those bells every fifteen minutes. If the bells are so numerous, and the mechanism so elaborate as to produce a musical chime or a melody at stated intervals, then we have those well-known effects with which the poet and the peasant are equally familiar—effects which many have felt as well as Cowper, but which few can express so well:—

> "How soft the music of those village bells,
> Falling at intervals upon the ear
> In cadence sweet! now dying all away,
> Now pealing loud again and louder still,
> Clear and sonorous as the gale comes on."

The merry peal which marks the holiday or the day of festivity is, as we have before observed, not rung by machinery connected with the church-clock, but by men, who pull ropes by which hammers are made to strike on a set of bells; each man attending to one bell, and the whole regulating their proceedings according to the rules of the curious art of bell-ringing. But where a melody is performed at fixed hours every day, then are the bells sounded by mechanism connected with the clock. He who hears the 149th Psalm played on the bells of St. Clement's church, or the other tunes on the bells of Cripplegate and Shoreditch churches, must not confound these performances with the ringing of a *peal* of bells.

In some churches, the bells play only one tune, at certain fixed hours of the day; in others, there are seven different tunes played, one for every day of the

week, each tune being repeated either six or eight times within the day to which it belongs. Such is the case in a clock which Messrs. Moore constructed for Christchurch, Hampshire, about four or five years ago; there is an octave of eight bells, which play seven different tunes, the tune being changed at midday. We believe that at Shoreditch church a similar arrangement exists; and also at Cripplegate, but with the addition of two more bells.

How are these tunes played? Such a question has doubtless occurred to many persons, and is deserving of an answer. If the reader has an opportunity of referring to No. 419 of 'The Penny Magazine,' he will find a brief description of 'musical snuff-boxes,' which will greatly aid in conveying an idea of the matter. In a musical-clock, as in a musical-box, there is a barrel studded in various parts of its surface with small pins or pieces of wire, placed apparently in a most unsymmetrical manner. These pins, during the rotation of the barrel, come in contact with small springs in the musical-box; but in the clock they catch against small levers connected with the hammers which strike the bells. Every pin moves a lever with sufficient force to enable the hammer to strike the bell; and therefore the artist's object is to place the pins in such order on the surface of the barrel as to lead to the striking of the bells in the proper order to form a tune, the bells being attuned to regular musical intervals.

In the article just referred to, there is an example given to show the principle on which the 'pricking' of the barrel, or the insertion of the pins in their proper places, is regulated. In modern church-clock factories the pricking is effected by a very beautiful machine; but a description of the old method adopted, though too rude for modern purposes, will perhaps be more readily understood by persons unaccustomed to machinery. A piece of writing-paper was taken, of such a size as to cover exactly the surface of the barrel; and on this were drawn, in a direction perpendicular to the axis of the barrel, as many parallel lines as there were notes in the tune, the lines being equidistant and corresponding to the levers which moved the hammers. They were marked at each end with the letters or notes of the gamut which they represented; and, according to the number of bars in the tune, as many spaces were made by lines drawn equidistant and parallel, intersecting the others at right angles. The junction of the ends of the paper, when applied round the barrel, represented one of these bar-lines. The spaces were again divided into smaller parts, for the minims, crotchets, and other notes in the tune, by lines parallel with the axis of the barrel. While the paper was lying on the table, the notes in the tune proposed to be laid on the barrel were marked by black ink dots on their respective lines, and in the same order as the bars of the music. After this was done, the paper was pasted on the barrel; and the note-lines then appeared like so many circles traced round the circumference of the barrel, while the bar-lines lay longitudinally on the surface of it. By this means the black ink dots were transferred and marked on the barrel by a punch or finger-drill, and the pins inserted at those spots.*

But where many tunes are played by one barrel, this primitive mode is inefficient. The principle, however, may be understood from it. The barrels 'pricked' for several tunes by the modern machine are so connected with the mechanism of the clock as to shift a little when the tune is changed, so that the hammers may be acted on by a different set of pins from those in use during the performance of the former tune; indeed, this shifting of the barrel is the circumstance which changes the tune.

* Reid, 'Treatise on Clock and Watch Making.

So far we have glanced over the main parts of the mechanism of a clock; but we cannot treat of the 'striking' machinery without devoting a page to the bells themselves, the vast sonorous masses for the sounding of which so much mechanism is required. This will take us from the clock-factory to the church-bell foundry, of which the only one in London is that of Messrs. Mears in Whitechapel.

All bells are made of a compound of copper and tin, and all are cast in moulds. A bell-foundry exhibits an earthen floor, excavated in parts to a depth of several feet, and having furnaces in which the metal is melted. At Messrs. Mears's foundry there is one furnace which will melt ten tons of metal at once, and another of smaller size. In this larger furnace was melted the metal for the "Great Tom of Lincoln," the largest bell in England except the "Great Tom of Oxford." The latter weighs seventeen thousand pounds, whereas the great bell of St. Paul's amounts only to between eleven and twelve thousand pounds. The new "Great Tom of Lincoln" (twelve thousand pounds) replaced, in the year 1835, the old bell of the same name, which was not so heavy by a ton. The thickness of the metal in bells of this kind varies so greatly that the weight cannot be judged from their size. St. Paul's bell, for example, is much larger than the "Great Tom of Lincoln," but is not so heavy; but all the weights here indicated sink into insignificance when compared with that of some of the Russian bells, 50,000, 124,000, 144,000, 288,000, 432,000 lbs.; these are the weights of some of the Russian bells. (See 'Penny Magazine,' No. 163.)

Both the shape of the bell and the proportions of the two metals are regulated so as to produce the most sonorous effects. There are about four parts of copper to one of tin. The tin is usually brought to the foundry in blocks from the mining districts, and the copper is old ship-sheathing and other fragments. These two metals are melted together in a reverberatory furnace, that is, one in which the flame and heated air pass over and upon the substance to be melted, instead of being applied underneath it. A very large volume of flame is kept up from a fire of dry billet-wood, and the heat from this is found to be less injurious to the metal than that of a common furnace. The metal remains in the furnace till it assumes the appearance of liquid fire, when it is ready for casting.

The mould into which the metal flows to form the bell is thus made:—A rough centre is built up of brickwork, at the bottom of a pit adjacent to the furnace, the mass being somewhat smaller than the interior diameter of the bell. This is coated with a particular kind of clay, which is shaped by gauges to the exact size and form of the interior of the bell; and on its surface is stamped any device which is to appear on that interior. This heart or core is then thoroughly dried, preparatory to the application of another layer of composition. The second layer is exactly the thickness of the intended bell; and is moulded, by gauges and other tools, till its outer surface presents precisely the size, form, and device of the intended exterior of the bell. A little dry tan-dust is sprinkled on the core previous to the application of this second layer, in order that the two portions of clay or earth may not adhere too closely. Matters are now ready for the application of a third layer of clay. This is of considerable thickness, and is laid over the intermediate stratum of clay, with a sprinkling of tan-dust, as in the former case. All these arrangements being made, and the clay thoroughly dried, the outer layer or case is lifted off the intermediate one, and the latter is picked or cut off the inner one piecemeal. The effect which is produced by these contrivances may be thus illustrated:—If we take three basins or cups of different sizes, and

invert them one over another, we may represent the bell-mould in its built-up form; but if the *middle* basin be removed, there will be a vacancy between the other two. The vacancy thus produced in the bell-mould is that into which the metal is poured, a hole being left at the top for that purpose, and two others for the escape of air as the metal enters.

All this is done in the casting-pit, which is then filled up with loam or earth to the top of the mould, the height of which is nearly equal to that of the orifice in the furnace. A shallow channel is cut in the loam from the furnace to the orifice of the mould; the earth which stops the hole in the furnace is cut away; and the melted metal, flowing from the furnace along the channel, fills the mould.

In some parts of Germany the casting of a bell is made a matter of much ceremony; the bell-founder inviting a large circle of friends to witness the scene, which commences with a prayer, and terminates with rejoicing. Schiller made this the subject of one of his finest ballads, the 'Song of the Bell,' many stanzas of which vividly portray the process of founding. We may select two, as relating, the first to the appearance of the pit when the mould or moulds are earthed in, and the second to the melting of the metal:—

"Fast immured within the earth,
Fix'd by fire the clay-mould stands;
This day the bell expects its birth,
Courage, comrades! ply your hands.
Comrades! ceaseless from your brow,
Ceaseless must the sweat-drop flow.
If by his work the master's known,
Yet Heaven must send the blessing down.

Billet of the fir-wood take,
Every billet dry and sound,
That flame, a gather'd flame awake,
And vault with fire the furnace round.
Quickly cast the copper in,
Quickly cast due weight of tin,
That the bell's tenacious food
Rightly flow in order'd mood."

In our concluding cut the casting-pit is represented with eight bell-moulds, for the casting of the same number of bells. We saw these bells cast a few days after the drawing was made, the pit having been filled with loam in the interim. It is a sight worth a visit to see the furnace full of liquid fiery white metal, the narrow jet pouring out at the orifice, the stream of liquid fire running along the channel, and the bubbling of the metal as it flows into the mould. If the bells be large, only one is cast at one time in the pit; but several smaller ones, varying from three or four hundredweights to twelve hundredweights each, as was the case in this instance, can be cast at once, a gutter being carried from the hole in the furnace to the mouth of each mould.

The bell is cast in a complete state, but it requires a little adjustment to regulate its tone. If a set of bells are to be made, having intervals of tones and semitones, the requisite adjustment is made by reducing the diameter at the edge when the tone is too low, and reducing the thickness at the part where the hammer strikes when the tone is too acute. This reduction is made by chipping away the metal with a sharp-pointed hammer.

Casting-pit of a Bell-Foundry.]